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INTERPARAMETER STATISTICAL ANALYSIS OF SURFACE WIND SPEED, TOTAL OPAQUE CLOUD COVER, AND MAXIMUM WIND SPEED ALOFT AT CAPE KENNEDY, FLORIDA

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By Orvel E. Smith, George C. Marshall Space Flight Center, Lawrence E. Truppi and Harold L. Crutcher, U. S. Weather Bureau, National Weather Records Center, Asheville, North Carolina.

ABSTRACT

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This report provides a monthly analysis of the statistical relationships of surface wind, winds aloft and total opaque cloud cover at Cape Kennedy. These data are based on five years of record, January 1957 through December 1961, and represent surface observations of wind speed and total opaque cloud cover coincident with RAWIN observations of maximum wind speeds in the 10 to 15 km layer. Data are presented as percentage occurrence of "go" to "no go" conditions where a favorable combination of all three parameters as to vehicle launch criteria represents a "go" condition, and a combination with one or more parameters unfavorable to vehicle launch is classified as a "no go" condition. The vehicle launch criteria have been arbitrarily chosen for the purpose of this report. author

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AERO-ASTROPHYSICS OFFICE
AERO-ASTRODYNAMICS LABORATORY

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INTERPARAMETER STATISTICAL ANALYSIS OF SURFACE WIND SPEED, TOTAL OPAQUE CLOUD COVER, AND MAXIMUM WIND SPEED ALOFT AT CAPE KENNEDY, FLORIDA

SUMMARY

This report provides a monthly analysis of the statistical relationships of surface wind, winds aloft and total opaque cloud cover at Cape Kennedy. These data are based on five years of record, January 1957 through December 1961, and represent surface observations of wind speed and total opaque cloud cover coincident with RAWIN observations of maximum wind speeds in the 10 to 15 km layer. Data are presented as percentage occurrence of "go" or "no go" conditions where a favorable combination of all three parameters as to vehicle launch criteria representsa "go" condition, and a combination with one or more parameters unfavorable to vehicle launch is classified as a "no go" condition. The vehicle launch criteria have been arbitrarily chosen for the purpose of this report.

This report was prepared as a result of investigations conducted under NASA Government Order Number H-3621 with the U. S. Weather Bureau.

SECTION I. INTRODUCTION

The rapid development of space vehicles and missiles has created an urgent demand for more information about critical atmospheric parameters affecting launches. These include (1) surface wind speed*affecting lift-off, (2) opaque cloud cover critical for optical tracking or observation, and (3) high wind speeds aloft in the 10 to 15 km layer affecting vehicle structure and control through this region. Previous statistical analyses have treated each of these atmospheric variables independently of each other, (References 1, 2, 3, and 4). This report is a first attempt to show the relationship between the three atmospheric parameters most often of concern in launching a space vehicle. This work was done in hopes that there might appear specific months, seasons or times of day when favorable combinations of surface wind speed, cloud cover and upper winds are more frequent, and it might be feasible to schedule launching to take advantage of such periods.

* For the purposes of this report surface wind is considered to be a two minute time average wind speed referenced to 60 feet above natural grade.

A condition where all three parameters are favorable is classified as a "go" condition. Combinations of one or more unfavorable parameters are classified as "no go" conditions, or conditions when launchings could not take place due to one or more parameters exceeding a critical limit. It is anticipated that the national aerospace program missions for Research and Development (R&D) vehicles and missions for the final versions of these vehicles will have specific requirements for a wide range of atmospheric conditions. For example, a manned Apollo mission may make more stringent requirements for lesser amounts of clouds than would the flight test of an R&D vehicle not requiring optical tracking. Again the mission of a specific R&D vehicle may require light winds aloft, say, less than 60 m/sec in the 10-15 km altitude region, and camera tracking. This broad spectrum of anticipated mission requirements dictates the wide range of statistics tabulated in this paper for the three atmospheric parameters: (1) surface winds, (2) cloud amounts, and (3) maximum winds in the 10-15 km altitude region.

Furthermore, a basic objective in presenting a large combination of the statistics for these three parameters is to assist program managers in arriving at decisions as to when is the best time to launch a vehicle with special mission requirements which are affected by these atmospheric conditions. To fulfill this objective, arbitrary limits were used for the "go" and "no go" conditions of which some should be representative of actual operating conditions. The selection of "go" and "no go" conditions as presented in this paper is made to satisfy present requirements and perhaps some future requirements. If the need arises, other criteria may be chosen and the resulting statistics determined.

SECTION II. DATA

A. Sources

Primary data sources were punched cards derived from original surface weather records and RAWIN records at the National Weather Records Center, Asheville, North Carolina. Upper wind data were taken from the 0000 GMT and 1200 GMT RAWIN observations at Cape Kennedy from January 1957 to December 1961. Surface data, wind speed and total opaque cloud cover were taken from hourly surface observations coincident with the RAWIN observations, that is, 0700 local standard time (1200 GMT) and 1900 local standard time (0000 GMT). Hereafter, local standard time is noted as LST and is understood to be Eastern Standard Time.

B. Processing and Computation

All data, surface and RAWIN, were subjected to a checking program using electronic data processing equipment. If individual observations fell outside predetermined limits, these were indicated and the original records re-examined.

The largest total opaque cloud cover amount and highest surface wind speed which occurred during 2 hours before and after the RAWIN release time were chosen for this analysis. This classification of cloud amounts and surface winds as being coincident with rawin measurements leads to a statistical bias resulting in the occurrence of a higher frequency of cloud cover than is given by Reference 1, which treated the statistics of cloud cover for each hour. The resulting bias is a conservatism in the criteria for "go" conditions. This bias is considered justifiable due to the inherent variability of surface wind and clouds over short time periods. Another factor is that the rawinsonde balloon is not always released on the hour and it may take as much as a half an hour to reach the altitude of the highest cloud layer.

Processing consisted of determining the maximum wind speed observed between 10 and 15 km on each RAWIN flight and noting the surface wind speed and total cloud cover within ±2 hours of the RAWIN observation. Upper wind speeds were grouped into class intervals of 10 meters per second (mps) as follows:

0-10
11-20
21-30
31-40
41-50
51-60
61-70
71-80
81-90
$>$ 90.

For each of the above class intervals, frequency and percentage frequency, coincident surface wind speed and total cloud cover were tabulated in the form of a two-way frequency and percentage frequency distribution as follows:

			Surface Wind Speed (mps)				
			0-3	4-6	7-9	10-12 ...	+ 30
		f					
	0-1	%f	--	--	--	--	--
		f					
Total	2-3	%f	--	--	--	--	--
		f					
opaque	4-5	%f	--	--	--	--	--
		f					
Cloud cover	6-7	%f	--	--	--	--	--
		f					
(tenths)	8-9	%f	--	--	--	--	--
		f					
	10	%f	--	--	--	--	--

A separate two-way distribution of surface data was computed for each class interval for each of the RAWIN times (0700 and 1900 LST) for each month for five years. Therefore, this statistical analysis was produced as a three-way frequency or percentage frequency distribution of upper wind speed versus surface wind speed versus total cloud amount.

Now, given the "go" or "no go" limits for the three parameters, percentage of occurrence can be found from the three-way distribution. For example, suppose launch requirements were a surface wind less than 6 mps, total cloud cover less than 3/10, and a maximum wind speed aloft of 60 mps or less. For January at 0700 LST the percentage occurrence of all three limits can be found by adding the percentage frequencies in the two-way surface distributions corresponding to the 0-3, 4-6 class intervals of wind speed and the 0-1, 2-3 class intervals of cloud cover at each of the upper wind class intervals of 0-10, 11-20, 21-30, 31-40, 41-50 and 51-60 mps. Addition of such percentages can be made because the number of observations of each parameter is equal. However, with such an accumulation of percentages, rounding errors may become apparent. In the accompanying tables, percentages may contain errors of ±2 percent. This is most apparent in the combination of data for the two hours, 0700 and 1900 LST.

C. Presentation

Data are presented using hypothetical vehicle launch criteria for the three atmospheric parameters. Percentage of occurrence of "go" and "no go" conditions is computed at 0700 and 1900 LST for each month at Cape Kennedy using data from five years of record.

Wind speeds are in meters per second (mps) where 1 mps = 1.94 knots = 2.24 mph.

SECTION III. ANALYSIS

The object of the analysis is to select some reasonable values of surface wind speed, cloud amount and upper wind speed, and to present percentage occurrence of "go" and "no go" conditions in tabular form throughout the year. In this way any seasonal or diurnal trends would be discernible. Moreover, when one of the parameters is changed, the effect becomes apparent by comparison with other tables. By presenting various combinations of "no go" situations, the critical parameters should be apparent.

Table I shows the variations of the three parameters throughout the year. The most favorable month is July at 0700 LST, and a substantial difference is observed between morning and evening in the summer months, May through September. From October through April, the evening observation, 1900 LST, has a higher percentage of "go" conditions than does the 0700 LST observation. If both observations are combined, July appears as the most favorable month, and March the least. The "no go" list of combinations reveals that total cloud cover (C_2) is the major cause of unfavorable conditions, and the upper wind (U_2) limit was exceeded mostly in winter and spring with the largest percentage in March.

In Tables II through VIII the format is the same. Parameter limits are increased one at a time through succeeding tables. In Table II the "go" limit for cloud cover has been extended to accept amounts equal to or less than 5/10. This change causes a substantial increase in "go" conditions as indicated by an increase in July from 37.9 percent in Table I to 53.6 percent in Table II. As a possible explanation, ground observers may tend to classify partly cloudy skies as 5/10, and if a value of 5/10 is accepted as a "go" condition, the percentage of favorable occurrences jumps considerably.

In Table III the limit of upper wind is similar to Table I with the exception that the limit of upper wind speed has been increased from 60 mps to 80 mps. This affects the winter and spring months almost exclusively with the greatest increase in "go" conditions occurring in March, increasing from 19.8 percent to 27.9 percent. It is interesting to note that upper winds in excess of 80 mps (155 knots) can cause "no go" conditions in March 2.5 percent of the time at 0700 LST.

If the limit of cloud cover is increased again from 3/10 to 5/10 along with the increase of upper wind speeds to 80 mps, Table IV illustrates the result. With the acceptance of a greater amount of cloud cover, the effects of the upper winds and the surface winds are revealed. Although small percentages are involved, upper winds are observed to affect launch conditions in January, February, March, and December, and the influence of surface wind speed is seen in all months with a maximum of 11.2 percent in February.

Tables V through VIII repeat the changes of cloud cover and upper wind speed shown in Tables I through IV except that surface wind speed, which was held at 6 mps in the first set, is increased to 9 mps (17 knots). Table V is the same format as Table I, with the exception of the increase in surface wind speed. The result is a small increase of "go" conditions in all seasons. As the surface wind speed becomes less critical, the importance of uppeı wind speed and total cloud cover becomes evident. Upper winds, particularly in spring and winter, create an increased percentage of "no go" occurrences.

In Table VI total cloud cover up to and including 5/10 is accepted. This permits the upper wind speeds in winter and spring to show their limiting effect. If a space vehicle could not be launched with maximum upper winds greater than 60 mps in the 10 to 15 km level, then cancellation would amount to 17.5 percent of the time in March at 1900 LST.

Table VII illustrates conditions with cloud amounts 3/10 or less and upper wind limits raised to 80 mps. It is evident that very few "no go" situations result from wind over 80 mps even in spring. Cloud cover is evident as the main problem particularly in the summer. In June, 75 percent of the time launching would not be possible because of cloud cover.

Table VIII has the most liberal limits. It is apparent that throughout the year the chances are about 50-50 for "go" conditions at Cape Kennedy. The morning hours in the summer are best with a maximum of 66.3 percent in July, but the evening hours in summer are the poorest with June at 34.0 percent. Critical upper winds over 80 mps are only slightly evident in winter or early spring.

The last table, Table IX, shows the percentage frequency of occurrence of the limits used. The values are independent of all other parameters. For example, April at 0700 LST if the surface wind speed limit was 6 mps or less, we could expect "go" conditions 80 percent of the time if cloud cover and upper wind limits were ignored. Or, it could be stated that this limit of surface wind speed would result in "no go" conditions 20 percent of the time regardless of coincident cloud cover amounts or upper wind speed. This table illustrates the importance of cloud amount criteria throughout the year at Cape Kennedy, and the increase in "go" conditions when the limit is increased to 5/10 is also apparent. It is interesting to note that an upper wind speed limit of 60 mps from December to April can result in more "no go" situations than a surface wind limit of 6 mps.

The percentages shown in these tables are empirical. No attempt has been made to assess the statistical bounds of confidence on the tabular values presented. Where percentages between categories are being compared and are small, the difference should not be given much consideration. A second five-year sample would be expected to show small differences in occurrence of comparable categories.

SECTION IV. CONCLUSIONS

The increasing use of electronic computing machines permits the consideration of computing the probability of encountering "go" or "no go" situations produced by any combination of atmospheric parameters at any present or future launch sites, if meteorological data are available. This study using arbitrary limits of surface wind speed, total opaque cloud cover and maximum upper wind speed observed in the 10-15 km layer at Cape Kennedy, Florida, illustrates how "go" and "no go" conditions vary with season, time of day, and of course the magnitude of the limits. It must be remembered that these data are peculiar to Cape Kennedy; that is, its latitude, its semi-tropical climate, and its exposure to the Atlantic Ocean determine the variations of "go" and "no go" conditions throughout the year. Perhaps a launch site with a drier climate would have a much higher percentage of "go" conditions, since it appears that total cloud cover is the most significant cause of "no go" conditions at Cape Kennedy.

Because of selected criteria, it is possible to "tailor" a study of this type to fit our present and future space vehicles or missiles, or to compare different launch sites.

Of the three parameters discussed, total opaque cloud cover appears as the most restrictive. Although there is little seasonal variation, a diurnal trend is apparent within each month. In the six coldest months, the afternoon period is the most favorable, while in the warmer half of the year the morning has the least cloud cover. There is a definite seasonal trend in winds aloft with the greatest speeds occurring in the winter and spring. The warmer months have the lowest surface wind speeds during the year. If a wind speed of 9 mps is acceptable then limitation due to this parameter is small.

In presenting this original work on the probability of the simultaneous occurrence of surface winds, winds aloft, and cloud amounts for Cape Kennedy, it is recognized that the value this study has to the National Space Program is directly related to how the statistics are presented and are eventually used in mission planning. Inquiries as to interpretation of these statistics and their relative significance to each other for particular space mission program planning should be directed to Chief, Aero-Astrophysics Office, Aero-Astrodynamics Laboratory, George C. Marshall Space Flight Center, Huntsville, Alabama.

TABLE I

INTERPARAMETER STATISTICAL ANALYSIS OF SURFACE WINDS, CLOUDS AND WINDS ALOFT AT CAPE KENNEDY

GO (S_1 = Surface Wind $\leq$ 6 mps. (C_1 = Cloud Cover $\leq$ 3/10 (U_1 = Upper Wind $\leq$ 60 mps.

NO GO (S_2 = Surface Wind > 6 mps. (C_2 = Cloud Cover > 3/10 (U_2 = Upper Wind > 60 mps.

PERCENTAGE OCCURRENCE

	Mo.	Jan.		Feb.		Mar.		Apr.		May		June		July		Aug.		Sept.		Oct.		Nov.		Dec.	
	Hr.	07	19	07	19	07	19	07	19	07	19	07	19	07	19	07	19	07	19	07	19	07	19	07	19
GO	$S_1U_1C_1$	23.3	26.4	16.8	23.9	16.2	25.4	24.6	30.9	31.2	27.9	26.2	21.3	47.6	28.9	44.5	23.3	32.7	28.1	36.4	37.3	34.0	40.1	25.8	33.1
NO GO	$S_1U_2C_1$	7.6	8.3	8.4	7.7	6.3	13.2	3.3	4.1	.6	.6									.6	1.9		1.4	4.4	10.1
	$S_1U_1C_2$	36.6	34.7	33.5	29.2	34.7	28.7	40.5	38.0	57.6	59.9	69.0	70.0	50.5	64.9	55.5	69.9	59.2	60.6	47.4	44.5	52.4	43.6	51.0	43.2
	$S_2U_1C_1$	1.8	4.9	5.6	3.5	1.2	2.5	4.7	4.2	2.5	3.0		2.0	1.3	1.2			.7	1.3	1.2	3.1	1.4	2.0	5.1	
	$S_2U_2C_1$	3.0	2.5	4.2	5.6	3.1	4.3		.7															1.3	
	$S_2U_1C_2$	9.4	5.1	14.0	14.7	12.0	6.3	9.4	8.7	7.5	8.0	4.8	6.7	.6	5.0		6.8	7.4	10.0	13.2	13.2	10.8	12.9	6.8	6.9
	$S_1U_2C_2$	13.9	14.4	10.5	13.3	20.8	15.3	11.4	8.7		.6									1.2		.7		5.6	4.9
	$S_2U_2C_2$	4.4	3.7	7.0	2.1	5.7	4.3	6.1	4.7	.6												.7			1.8

ALL OBSERVATIONS COMBINED

	Mo.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
GO	$S_1U_1C_1$	25.0	20.4	19.8	27.8	29.6	23.2	37.9	33.8	30.4	36.8	37.1	29.3
NO GO	$S_1U_2C_1$	8.0	8.1	9.8	3.7	.6					1.3	.7	7.3
	$S_1U_1C_2$	35.2	31.1	32.5	39.0	58.6	70.0	58.0	62.8	59.9	45.9	47.8	47.0
	$S_2U_1C_1$	3.4	4.6	1.9	4.5	2.8	1.0	1.3		1.0	2.2	1.7	2.6
	$S_2U_2C_1$	2.8	4.9	3.7	.4								.7
	$S_2U_1C_2$	7.3	14.4	9.2	9.1	7.8	5.8	2.8	3.4	8.7	13.2	11.9	6.9
	$S_1U_2C_2$	14.2	11.9	18.1	10.1	.3					.6	.4	5.3
	$S_2U_2C_2$	4.1	4.3	5.0	5.4	.3						.4	.9

TABLE II

INTERPARAMETER STATISTICAL ANALYSIS OF SURFACE WINDS, CLOUDS AND WINDS ALOFT AT CAPE KENNEDY

GO (S_1 = Surface Wind $\leq$ 6 mps. (C_1 = Cloud Cover $\leq$ 5/10 (U_1 = Upper Wind $\leq$ 60 mps.

NO GO (S_2 = Surface Wind > 6 mps. (C_2 = Cloud Cover > 5/10 (U_2 = Upper Wind > 60 mps.

PERCENTAGE OCCURRENCE

	Mo. / Hr.	Jan. 07	Jan. 19	Feb. 07	Feb. 19	Mar. 07	Mar. 19	Apr. 07	Apr. 19	May 07	May 19	June 07	June 19	July 07	July 19	Aug. 07	Aug. 19	Sept. 07	Sept. 19	Oct. 07	Oct. 19	Nov. 07	Nov. 19	Dec. 07	Dec. 19
GO	$S_1U_1C_1$	33.1	36.3	25.5	29.7	25.1	31.4	36.6	38.9	45.5	39.0	53.0	30.8	65.6	40.9	65.6	37.8	56.5	40.9	46.7	47.4	49.0	51.6	39.9	41.9
NO GO	$S_1U_2C_1$	8.8	12.1	10.5	11.2	12.0	13.8	4.7	6.1	.6	.6									1.2	1.9		1.4	5.0	10.7
NO GO	$S_1U_1C_2$	23.8	24.8	24.8	23.4	25.8	22.7	28.5	30.0	43.3	48.8	42.2	60.5	32.5	52.9	34.4	55.4	35.4	47.8	37.1	34.4	37.4	32.1	36.9	34.4
NO GO	$S_2U_1C_1$	2.4	4.9	8.4	4.2	2.5	2.5	5.4	4.9	3.8	4.8		3.4	1.3	1.2		.6	1.4	2.6	3.7	5.6	2.8	3.4	6.3	
NO GO	$S_2U_2C_1$	3.0	3.1	4.2	7.7	3.7	4.3	2.1	2.7	.6														1.3	
NO GO	$S_2U_1C_2$	8.8	5.1	11.2	14.0	10.7	6.3	8.7	8.0	6.2	6.2	4.8	5.3	.6	5.0		6.2	6.7	8.7	10.7	10.7	9.4	11.5	5.6	6.9
NO GO	$S_1U_2C_2$	12.7	10.6	8.4	9.8	15.1	14.7	10.0	6.7		.6									.6		.7		5.0	4.3
NO GO	$S_2U_2C_2$	4.4	3.1	7.0		5.1	4.3	4.0	2.7													.7			1.8

ALL OBSERVATIONS COMBINED

	Mo.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
GO	$S_1U_1C_1$	34.4	28.4	28.1	37.8	41.7	41.9	53.6	51.8	48.5	46.9	50.1	40.8
NO GO	$S_1U_2C_1$	10.5	10.9	12.9	5.4	.6					1.6	.7	7.9
NO GO	$S_1U_1C_2$	25.8	23.2	24.4	29.0	46.6	51.3	42.3	44.8	41.8	35.8	34.8	35.5
NO GO	$S_2U_1C_1$	3.7	6.3	2.5	5.2	4.3	1.7	1.3	.3	2.0	4.7	3.1	3.2
NO GO	$S_2U_2C_1$	3.1	6.0	4.0	2.4	.3							.7
NO GO	$S_2U_1C_2$	7.0	12.6	8.5	8.4	6.2	5.1	2.8	3.1	7.7	10.7	10.5	6.3
NO GO	$S_1U_2C_2$	11.7	9.1	14.9	8.4	.3					.3	.4	4.7
NO GO	$S_2U_2C_2$	3.8	3.5	4.7	3.4							.4	.9

TABLE III

INTERPARAMETER STATISTICAL ANALYSIS OF SURFACE WINDS, CLOUDS AND WINDS ALOFT AT CAPE KENNEDY

GO (S_1 = Surface Wind $\leq$ 6 mps. (C_1 = Cloud Cover $\leq$ 3/10 (U_1 = Upper Wind $\leq$ 80 mps.

NO GO (S_2 = Surface Wind $>$ 6 mps. (C_2 = Cloud Cover $>$ 3/10 (U_2 = Upper Wind $>$ 80 mps.

PERCENTAGE OCCURRENCE

	Mo.	Jan.		Feb.		Mar.		Apr.		May		June		July		Aug.		Sept.		Oct.		Nov.		Dec.	
	Hr.	07	19	07	19	07	19	07	19	07	19	07	19	07	19	07	19	07	19	07	19	07	19	07	19
GO	$S_1U_1C_1$	31.9	34.1	24.8	30.2	18.9	36.8	27.5	34.3	31.8	28.5	26.2	21.3	47.6	28.8	44.5	23.9	32.7	28.1	37.0	39.2	34.0	40.2	29.6	42.2
NO GO	$S_1U_2C_1$		.6	1.4	1.4	2.5	1.8																	.6	.6
NO GO	$S_1U_1C_2$	47.0	47.9	40.2	38.3	54.1	43.4	52.3	46.7	57.6	60.5	69.0	70.0	50.5	65.0	35.5	69.3	59.2	60.6	48.0	44.5	53.1	44.2	56.6	48.5
NO GO	$S_2U_1C_1$	4.2	6.1	8.4	6.3	3.7	5.6	4.7	4.9	2.5	3.0		2.0	1.3	1.2			.7	1.3	1.2	3.1	1.4	2.7	6.4	
NO GO	$S_2U_2C_1$	.6	1.3	1.4	2.8	.6	1.2																		
NO GO	$S_2U_1C_2$	12.6	8.2	17.5	16.1	17.1	9.4	14.8	12.7	8.1	8.0	4.8	6.7	.6	5.0		6.8	7.4	10.0	13.2	13.2	11.5	12.9	6.8	8.7
NO GO	$S_1U_2C_2$	2.5	1.2	2.8	4.2	2.5	.6		.7											.6					
NO GO	$S_2U_2C_2$	1.2	.6	3.5	.7	.6	1.2	.7	.7																

ALL OBSERVATIONS COMBINED

	Mo.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
GO	$S_1U_1C_1$	32.7	27.0	27.9	31.1	30.2	23.2	37.9	33.8	30.4	37.6	37.4	35.9
NO GO	$S_1U_2C_1$	.3	1.4	2.2									.6
NO GO	$S_1U_1C_2$	47.6	39.7	48.5	49.2	58.9	70.0	58.0	62.8	59.9	46.7	48.3	52.5
NO GO	$S_2U_1C_1$	5.2	7.4	4.7	4.8	2.8	1.0	1.3		1.0	2.2	2.1	3.2
NO GO	$S_2U_2C_1$	1.0	2.1	.9									
NO GO	$S_2U_1C_2$	10.4	16.8	13.3	13.8	8.1	5.8	2.8	3.4	8.7	13.2	12.2	7.8
NO GO	$S_1U_2C_2$	1.9	3.5	1.6	.4						.3		
NO GO	$S_2U_2C_2$	.9	2.1	.9	.7								

TABLE IV

INTERPARAMETER STATISTICAL ANALYSIS OF SURFACE WINDS, CLOUDS AND WINDS ALOFT AT CAPE KENNEDY

GO (S_1 = Surface Wind $\leq$ 6 mps.
(C_1 = Cloud Cover $\leq$ 5/10
(U_1 = Upper Wind $\leq$ 80 mps.

NO GO (S_2 = Surface Wind $>$ 6 mps.
(C_2 = Cloud Cover $>$ 5/10
(U_2 = Upper Wind $>$ 80 mps.

PERCENTAGE OCCURRENCE

	Mo.	Jan.		Feb.		Mar.		Apr.		May		June		July		Aug.		Sept.		Oct.		Nov.		Dec.	
	Hr.	07	19	07	19	07	19	07	19	07	19	07	19	07	19	07	19	07	19	07	19	07	19	07	19
GO	$S_1U_1C_1$	40.6	47.2	33.9	38.2	33.3	43.4	41.3	45.0	46.7	39.6	53.0	30.8	65.6	40.9	65.1	37.8	56.5	40.9	47.6	49.8	49.0	53.0	45.3	52.0
NO GO	$S_1U_2C_1$	.6	1.2	2.8	3.5	3.8	1.8																	.6	.6
	$S_1U_1C_2$	35.7	34.8	31.1	30.3	39.7	36.8	38.5	36.0	42.7	49.4	42.2	60.5	32.5	52.9	34.9	55.4	35.4	47.8	37.4	33.9	38.1	32.1	40.9	38.7
	$S_2U_1C_1$	4.8	6.7	11.2	8.4	5.6	5.6	6.8	6.9	4.4	4.8		3.4	1.3	1.2		.6	1.4	2.6	3.7	5.6	2.8	3.4	7.6	
	$S_2U_2C_1$	1.2	1.3	1.4	3.5	.6	1.2	.7	.7																
	$S_2U_1C_2$	12.0	7.6	14.7	14.0	15.2	9.4	12.7	10.7	6.2	6.2	4.8	5.3	.6	5.0		6.2	6.7	8.7	10.7	10.7	10.1	11.5	5.6	8.7
	$S_1U_2C_2$	1.9	.6	1.4	2.1	1.2	.6		.7											.6					
	$S_2U_2C_2$	3.2	.6	3.5		.6	1.2																		

ALL OBSERVATIONS COMBINED

	Mo.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
GO	$S_1U_1C_1$	44.0	35.6	38.3	43.2	42.9	41.9	53.6	51.8	48.8	48.5	51.0	48.7
NO GO	$S_1U_2C_1$	.9	3.2	2.8									.6
	$S_1U_1C_2$	35.0	30.9	38.3	37.1	46.3	51.3	42.3	44.8	41.5	35.8	35.1	39.7
	$S_2U_1C_1$	5.8	9.8	5.6	6.9	4.6	1.7	1.3	.3	2.0	4.7	3.1	3.8
	$S_2U_2C_1$	1.3	2.5	.9	.7								
	$S_2U_1C_2$	9.8	14.4	12.3	11.7	6.2	5.1	2.8	3.1	7.7	10.7	10.8	7.2
	$S_1U_2C_2$	1.3	1.8	.9	.4						.3		
	$S_2U_2C_2$	1.9	1.8	.9									

TABLE V

INTERPARAMETER STATISTICAL ANALYSIS OF SURFACE WINDS, CLOUDS AND WINDS ALOFT AT CAPE KENNEDY

GO (S_1 = Surface Wind $\leq$ 9 mps.
(C_1 = Cloud Cover $\leq$ 3/10
(U_1 = Upper Wind $\leq$ 60 mps.

NO GO (S_2 = Surface Wind > 9 mps.
(C_2 = Cloud Cover > 3/10
(U_2 = Upper Wind > 60 mps.

PERCENTAGE OCCURRENCE

	Mo.	Jan.		Feb.		Mar.		Apr.		May		June		July		Aug.		Sept.		Oct.		Nov.		Dec.	
	Hr.	07	19	07	19	07	19	07	19	07	19	07	19	07	19	07	19	07	19	07	19	07	19	07	19
GO	$S_1U_1C_1$	25.4	30.7	22.7	27.6	17.4	27.9	28.3	34.4	34.3	39.3	26.2	23.3	48.3	30.8	44.5	23.9	33.8	28.0	34.5	40.2	35.4	42.1	30.9	32.7
NO GO	$S_1U_2C_1$	10.0	10.8	11.9	10.5	9.4	16.9	3.3	5.5	.6	.6									.6	1.9		1.4	5.7	10.1
NO GO	$S_1U_1C_2$	45.1	39.2	43.0	39.5	44.9	35.0	49.3	46.0	63.9	57.9	72.4	76.7	51.7	69.2	55.5	74.9	64.8	72.0	62.5	57.9	62.5	56.5	57.2	50.5
NO GO	$S_2U_1C_1$		.6						.7		.6														
NO GO	$S_2U_2C_1$	.6		.7	2.1		.6																		
NO GO	$S_2U_1C_2$	.6	.6	4.2	4.9	1.8		1.3	.7	.6		1.4					1.2	1.4		1.2		.7		.6	
NO GO	$S_1U_2C_2$	17.1	17.5	16.8	14.7	25.9	18.4	17.5	12.0	.5	.5									1.2		.7		5.6	6.1
NO GO	$S_2U_2C_2$	1.2	.6	.7	.7	.6	1.2		.7													.7			.6

ALL OBSERVATIONS COMBINED

	Mo.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
GO	$S_1U_1C_1$	27.5	24.9	22.7	31.5	32.8	24.3	39.2	33.8	30.7	37.4	38.1	31.8
NO GO	$S_1U_2C_1$	10.4	11.2	13.2	4.4	.6					1.3	.7	7.9
NO GO	$S_1U_1C_2$	42.7	41.4	39.8	47.5	65.4	75.0	60.8	65.6	68.6	60.1	60.0	53.8
NO GO	$S_2U_1C_1$	.3			.4	.3							
NO GO	$S_2U_2C_1$	.3	1.4	.3									
NO GO	$S_2U_1C_2$	.3	4.6	.9	1.0	.3	.7		.3	.7	.6	.4	.3
NO GO	$S_1U_2C_2$	17.3	15.8	22.2	14.8	.6					.6	.4	5.9
NO GO	$S_2U_2C_2$	.9	.7	.9	.4							.4	.3

TABLE VI

INTERPARAMETER STATISTICAL ANALYSIS OF SURFACE WINDS, CLOUDS AND WINDS ALOFT AT CAPE KENNEDY

GO (S_1 = Surface Wind $\leq$ 9 mps.
(C_1 = Cloud Cover $\leq$ 5/10
(U_1 = Upper Wind $\leq$ 60 mps.

NO GO (S_2 = Surface Wind > 9 mps.
(C_2 = Cloud Cover > 5/10
(U_2 = Upper Wind > 60 mps.

PERCENTAGE OCCURRENCE

	Mo.	Jan.		Feb.		Mar.		Apr.		May		June		July		Aug.		Sept.		Oct.		Nov.		Dec.	
	Hr.	07	19	07	19	07	19	07	19	07	19	07	19	07	19	07	19	07	19	07	19	07	19	07	19
GO	$S_1U_1C_1$	34.8	40.6	33.9	33.9	26.6	33.6	41.6	42.2	49.3	42.2	53.0	34.0	66.3	42.1	65.6	38.4	57.9	43.5	49.4	52.8	51.8	55.0	47.2	41.9
NO GO	$S_1U_2C_1$	11.2	15.2	14.0	15.4	15.7	17.5	6.8	9.5	1.2	.6									1.2	1.9		1.4	6.3	10.7
	$S_1U_1C_2$	35.7	29.3	31.8	33.2	35.7	29.3	36.3	38.2	48.9	56.0	45.6	66.0	33.7	57.9	34.4	60.4	40.7	56.5	47.6	45.3	46.1	43.6	40.9	40.7
	$S_2U_1C_1$		.6						.7		.6														
	$S_2U_2C_1$	.6		.7	3.5		.6																		
	$S_2U_1C_2$	.6	.6	4.2	4.2	1.8		1.3	.7	.6		1.4					1.2	1.4		1.2		.7		.6	
	$S_1U_2C_2$	15.9	13.1	14.7	9.8	19.6	17.8	14.0	8.0		.6									.6		.7		5.0	6.1
	$S_2U_2C_2$	1.2	.6	.7		.6	1.2		.7													.7			.6

ALL OBSERVATIONS COMBINED

	Mo.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
GO	$S_1U_1C_1$	37.6	33.9	29.7	42.0	46.3	43.1	54.9	51.8	50.5	51.6	53.2	44.5
NO GO	$S_1U_2C_1$	13.2	14.7	16.6	8.2	.9					1.6	.7	8.5
	$S_1U_1C_2$	32.6	32.4	32.9	37.0	51.9	56.2	45.1	47.6	48.8	45.9	44.9	40.8
	$S_2U_1C_1$	.3			.4	.3							
	$S_2U_2C_1$	.3	2.1	.3									
	$S_2U_1C_2$	.6	4.2	.9	1.0	.3	.7		.6	.7	.6	.4	.3
	$S_1U_2C_2$	14.5	12.3	18.7	11.0	.3					.3	.4	5.6
	$S_2U_2C_2$	.9	.4	.9	.4							.4	.3

TABLE VII

INTERPARAMETER STATISTICAL ANALYSIS OF SURFACE WINDS, CLOUDS AND WINDS ALOFT AT CAPE KENNEDY

GO (S_1 = Surface Wind $<$ 9 mps.
(C_1 = Cloud Cover $\lesseqgtr$ 3/10
(U_1 = Upper Wind $\leq$ 80 mps.

NO GO (S_2 = Surface Wind $>$ 9 mps.
(C_2 = Cloud Cover $>$ 3/10
(U_2 = Upper Wind $>$ 80 mps.

PERCENTAGE OCCURRENCE

	Mo.	Jan.		Feb.		Mar.		Apr.		May		June		July		Aug.		Sept.		Oct.		Nov.		Dec.	
	Hr.	07	19	07	19	07	19	07	19	07	19	07	19	07	19	07	19	07	19	07	19	07	19	07	19
GO	$S_1U_1C_1$	34.5	39.9	33.2	36.1	23.6	41.8	31.9	38.2	34.9	30.9	26.2	23.3	48.3	30.8	44.5	23.3	33.8	28.0	35.4	41.3	35.4	43.5	36.0	42.2
NO GO	$S_1U_2C_1$	.6	1.9	2.1	2.8	3.1	3.0																	.6	.6
	$S_1U_1C_2$	59.4	54.6	53.5	48.5	68.4	51.6	66.1	58.3	64.5	68.5	72.4	76.7	51.7	69.2	55.5	75.5	64.8	72.0	62.8	58.7	63.2	56.5	62.8	56.6
	$S_2U_1C_1$	.6	.6		1.4		.6		.7		.6														
	$S_2U_2C_1$			.7	1.4																				
	$S_2U_1C_2$	1.2	1.2	4.2	4.9	1.8	1.2	1.3	1.4	.6		1.4					1.2	1.4		1.2		1.4		.6	.6
	$S_1U_2C_2$	3.1	1.8	5.6	4.9	2.5	1.8	.7	1.4											.6					
	$S_2U_2C_2$	.6		.7		.6																			

ALL OBSERVATIONS COMBINED

	Mo.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
GO	$S_1U_1C_1$	37.3	33.7	32.7	35.7	32.6	24.3	39.2	33.8	30.7	38.2	39.0	39.1
NO GO	$S_1U_2C_1$	1.3	2.9	3.1									.6
	$S_1U_1C_2$	56.8	50.8	59.9	61.4	66.8	75.0	60.8	65.6	68.6	60.9	60.3	59.7
	$S_2U_1C_1$	.6	.7	.3	.4	.3							
	$S_2U_2C_1$		1.1										
	$S_2U_1C_2$	1.2	4.6	1.5	1.4	.3	.7		.6	.7	.6	.7	.6
	$S_1U_2C_2$	2.5	5.8	2.2	1.1						.3		
	$S_2U_2C_2$	.3	.4	.3									

TABLE VIII

INTERPARAMETER STATISTICAL ANALYSIS OF SURFACE WINDS, CLOUDS AND WINDS ALOFT AT CAPE KENNEDY

GO (S_1 = Surface Wind $\leq$ 9 mps.
(C_1 = Cloud Cover $\leq$ 5/10
(U_1 = Upper Wind $\leq$ 80 mps.

NO GO (S_2 = Surface Wind > 9 mps.
(C_2 = Cloud Cover > 5/10
(U_2 = Upper Wind > 80 mps.

PERCENTAGE OCCURRENCE

	Mo.	Jan.		Feb.		Mar.		Apr.		May		June		July		Aug.		Sept.		Oct.		Nov.		Dec.	
	Hr.	07	19	07	19	07	19	07	19	07	19	07	19	07	19	07	19	07	19	07	19	07	19	07	19
GO	$S_1U_1C_1$	44.5	53.3	45.1	44.5	38.8	48.1	47.7	50.2	50.5	42.8	52.3	34.0	66.3	42.1	65.6	38.4	57.9	44.5	51.3	54.9	52.1	57.0	51.9	51.0
NO GO	$S_1U_2C_1$	1.2	2.5	3.5	5.6	4.4	3.0																	.6	.6
NO GO	$S_1U_1C_2$	49.4	41.2	41.6	40.1	53.2	45.3	50.3	46.3	48.9	56.6	46.3	66.0	33.7	57.9	34.4	60.4	40.7	55.5	46.9	45.1	46.5	43.0	46.9	47.8
NO GO	$S_2U_1C_1$	.6	.6		2.1		.6		.7		.6														
NO GO	$S_2U_2C_1$			.7	1.4																				
NO GO	$S_2U_1C_2$	1.2	1.2	4.2	4.2	1.8	1.2	1.3	1.4	.6		1.4					1.2	1.4		1.2		1.4		.6	.6
NO GO	$S_1U_2C_2$	2.5	1.2	4.2	2.1	1.2	1.8	.7	1.4											.6					
NO GO	$S_2U_2C_2$	.6		.7		.6																			

ALL OBSERVATIONS COMBINED

	Mo.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
GO	$S_1U_1C_1$	49.9	43.8	43.5	48.7	46.9	43.1	54.2	51.8	50.5	52.6	54.1	51.5
NO GO	$S_1U_2C_1$	1.9	4.6	3.7									.6
NO GO	$S_1U_1C_2$	44.2	41.6	49.2	48.4	52.5	56.2	45.8	47.6	48.8	46.5	45.2	47.3
NO GO	$S_2U_1C_1$	.6	1.1	.3	.4	.3							
NO GO	$S_2U_2C_1$		1.1										
NO GO	$S_2U_1C_2$	1.2	4.2	1.5	1.4	.3	.7		.6	.7	.6	.7	.6
NO GO	$S_1U_2C_2$	1.9	3.2	1.5	1.1						.3		
NO GO	$S_2U_2C_2$	.3	.4	.3									

TABLE IX

INTERPARAMETER STATISTICAL ANALYSIS OF SURFACE WINDS, CLOUDS AND WINDS ALOFT AT CAPE KENNEDY

PERCENTAGE FREQUENCY

Go Conditions	Jan.		Feb.		Mar.		Apr.		May		June		July		Aug.		Sept.		Oct.		Nov.		Dec.	
	07	19	07	19	07	19	07	19	07	19	07	19	07	19	07	19	07	19	07	19	07	19	07	19
$S_1 \leq 6$ mps.	79.4	83.3	70.2	73.6	77.2	81.2	80.0	82.1	89.0	88.4	95.3	91.4	98.0	93.4	99.8	92.9	91.4	87.3	85.0	83.2	87.4	85.5	86.1	91.1
$S_1 \leq 9$ mps.	96.1	98.1	95.6	92.0	97.2	97.2	98.8	98.2	99.2	99.3	98.7	100.0	99.9	99.9	99.8	98.7	98.1	98.6	98.5	99.9	98.8	100.0	99.0	99.3
$C_1 \leq 3/10$	36.1	41.8	35.3	40.9	27.0	44.9	32.1	39.4	34.9	32.0	26.1	23.3	48.4	30.3	44.4	23.2	33.3	28.1	35.4	41.9	35.4	43.3	36.7	43.2
$C_1 \leq 5/10$	46.9	55.9	48.6	52.8	43.0	51.2	48.9	52.2	50.4	44.2	52.8	34.0	66.5	42.5	65.0	38.6	57.4	43.5	50.8	54.8	52.1	56.6	52.7	52.2
$U_1 \leq 60$ mps.	70.3	70.3	69.4	70.8	63.1	61.8	79.4	82.0	98.9	98.7	100.0	100.0	100.0	100.0	99.9	100.0	100.0	100.0	98.1	98.2	98.7	98.7	88.4	82.5
$U_1 \leq 80$ mps.	95.5	96.1	90.7	90.7	93.5	94.7	99.4	98.7	100.0	100.0	-	-	-	-	-	-	-	-	99.3	100.0	100.0	100.0	99.3	99.3

ALL OBSERVATIONS COMBINED

Go Conditions	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
$S_1 \leq 6$ mps.	81.4	71.9	79.2	81.1	88.7	93.4	95.7	96.4	89.4	84.1	86.5	88.6
$S_1 \leq 9$ mps.	97.1	93.8	97.2	98.5	99.3	99.4	99.9	99.3	98.4	99.2	99.4	99.2
$C_1 \leq 3/10$	39.0	38.1	36.0	35.8	33.5	24.7	39.4	33.8	30.7	38.7	39.4	40.0
$C_1 \leq 5/10$	51.4	50.7	47.1	50.6	47.3	43.4	54.5	51.8	50.5	52.8	54.4	52.5
$U_1 \leq 60$ mps.	70.3	70.1	62.5	80.7	98.8	100.0	100.0	100.0	100.0	98.2	98.7	85.5
$U_1 \leq 80$ mps.	95.8	90.7	94.1	99.1	100.0	-	-	-	-	99.7	100.0	99.3

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INTERPARAMETER STATISTICAL ANALYSIS OF SURFACE WIND SPEED, TOTAL OPAQUE CLOUD COVER, AND MAXIMUM WIND SPEED ALOFT AT CAPE KENNEDY, FLORIDA

By Orvel E. Smith, Lawrence E. Truppi and Harold L. Crutcher

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